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COMPACT CIRCUIT ARRANGEMENT AND PROCESS FOR DEPOSITING CONTACT MATERIAL ON CONNECTING SURFACES

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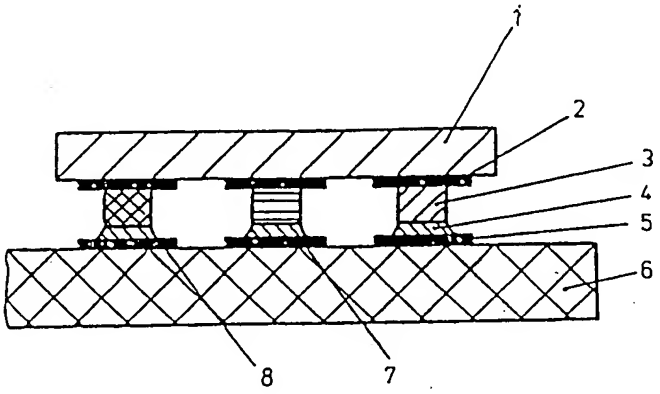
[Abstract]

The invention concerns a compact circuit arrangement with one or more circuits that are configured in one or more semiconductor materials or on substrates such as glass or ceramic and/or with one or more substrates or other semiconductor components and a process for the deposition of contact material on connecting surfaces in circuits or substrates for the purpose of producing compact circuit arrangements or for the production of electronic components. It is the purpose of the invention to increase the combinability of elements in a vertical direction, to

externally produce mound-elements of practically identical height and to connect them to the component that is to carry them. The task is solved according to the invention by isolating from a silicon disc or from a disc of some other semiconductor material individual conductive doped contact elements and by contacting with them the connecting surfaces of a circuit or of a substrate. Between the individual circuits or substrates that are contacting each other at least one functional element is positioned next to the contact elements.



Claims

1. Compact circuit arrangement with one or more circuits and/or one or more wiring carriers that have contact with and among each other characterized in that between the elements that are contacting in a vertical direction (1, 6, 9) next to the contact element (3) at least one functional element (7, 8, ...) is positioned.

2. Compact circuit arrangement according to Claim 1 with a temperature sensor, a Peltier element and a control circuit characterized in that between a circuit (1) and a wiring carrier (6), next to contact elements (3) out of a conductive doped semiconductor material that have been isolated from a semiconductor material disc, functional elements are positioned that are made from doped semiconductor material with the same dimensions as the contact elements, such as at least one p-type doped and one n-type doped functional element that are contacted with each other, and a diode doped as a temperature sensor.

3. Compact circuit arrangement according to Claim 1 with an oscillator quartz, preferably for a watch, with a battery and a liquid crystal display characterized in that the oscillator quartz (23), together with contact elements (3) that are made from a semiconductor material, and

potentially together with further functional elements, is positioned between the circuit (1) and the wiring carrier (6).

4. Compact circuit arrangement according to Claim 1 with optical couplers characterized in that parts of the optical couplers are manufactured to have approximately the same dimensions as the contact elements (3) that have been isolated from semiconductor discs.

5. Compact circuit arrangement according to Claim 1 for the modulation of polarized electromagnetic irradiation, with an integrated electrical frequency generator, a circuit for the control of the frequency generator and a double-refracting crystal, preferably CdTe, characterized in that the crystal together with the contact elements (3) of approximately the same dimensions is contacted between a circuit (1) and a wiring carrier (6).

6. Compact circuit arrangement according to Claim 1 with circuit elements that disrupt further functions and/or switch off a connected machine or installation, in the event of, in particular, unacceptable warming, of excessive or too little voltage or of irregular magnetic fields, characterized in that the sensors of the fail safe switch are contacted as functional elements (7.2, 7.3, 24) between the circuit (1) and the wiring carrier (6).

7. Compact circuit arrangement according to Claim 1 characterized in that one functional element or the functional elements have the same height as the contact elements.

8. Compact circuit arrangement according to Claim 1 characterized in that the functional elements and the contact elements are made from silicon, another semiconductor material or a ferroelectric material, a dielectric material or some other material with electronic application.

9. Compact circuit arrangement according to Claim 1 characterized in that a functional element features at least two connections at its connecting side.

10. Compact circuit arrangement according to Claim 1 characterized in that one or more functional elements and contact elements are attached to only one component and, other than that, are wired (19, 20).

11. Compact circuit arrangement according to Claim 1 characterized in that a functional element is a p-type and/or an n-type conductor and in that as a functional element a diode (16) or a resistor (7) or an electrochemical energy source (17) or a capacitor (8) are provisioned.

12. Compact circuit arrangement according to Claim 3 characterized in that between the circuit and the wiring carrier at least one Peltier element (25) is provisioned that consists of one p-type doped and one n-typed doped semiconductor element.

13. Compact circuit arrangement according to Claim 6 characterized in that as a functional element at least one thermistor element (24) or one varistor element (7.3) or one magnetoresistor element (7.2) or one functional element out of Piezo ceramics is provisioned.

14. Compact circuit arrangement according to Claim 4 characterized in that the luminescent diodes (16.5) and the photo diodes (16.2/3) in circuit (1) and in the wiring carrier (6)

are both preferably out of GaAs and doped and that between them transparent bodies (7) are installed that have the same dimensions as the contact elements (3).

15. Process for depositing contact material on connecting surfaces of circuit or substrates with mound elements being externally produced and contacted on the component on which the material is to be deposited, for the production of compact circuit arrangements or for the production of electronic components characterized in that doped conductive contact elements are isolated from a silicon disc or from a disc of some other semiconductor material, for the purpose of depositing the material.

16. Process according to Claim 15 characterized in that the contact surfaces of the components on which material is to be deposited are coated with aluminum and in that the contact formation is accomplished by means of thermocompression.

17. Process according to Claim 15 characterized in that the connecting surfaces of the components to be contacted and/or the contact elements are coated with one or more solderable layers.

18. Process according to Claim 15 characterized in that the contact elements are attached with an electrically conductive glue.

19. Process according to Claim 15 characterized in that the contact elements are contacted by means of hardening amalgamating layers.

20. Process according to Claims 15-19 characterized in that the connecting surfaces of the components on which material is to be deposited are coated with an aluminum coating, that the contact elements are attached to them by means of thermocompression bonding and that the contact surfaces of the contact elements with another component, which is to be contacted to the element on which material is to be deposited, are coated with one or several layers that are required according to items 17-19.

The invention concerns a compact circuit arrangement with one or several semiconductor materials or with circuits configured on substrates such as e.g. glass or ceramic and/or with one or several substrates or other semiconductor components and a process for depositing contact material on connecting surfaces for the production of compact circuit arrangements or for the production of electronic components.

Several circuit arrangements are already known in which integrated circuits are connected with each other and with substrates and in which the substrates are connected with each other. When the substrates are simultaneously configured to serve as wiring carriers a very compact circuit arrangement results.

The elements are either contacted to each other by way of bonded mounds in a very short and space-saving manner or by way of electrical conductors (wiring bridges, foil conductors

etc.). The connecting elements serve also as electrical contacts, in part they also provide the mechanical bonding and heat conduit. Compact circuit arrangements are also known in which, following the concept of "green ceramics" (DE-OS 2745 582), the metallized current carrying lines and connections between the conducting levels are substituted by glass-optical connections. Both for the production of compact electronic circuit arrangements in which several circuits are contacted on one or more wiring carriers or substrates and for the contacting of several substrates among each other or in so-called internal conductor bonding of circuits for the production of electronic components, e.g. by way of carrier film bonding or by way of wire contacting, it is necessary in many cases to build up "mounds" on the circuit or the substrate, i.e. to deposit contact material on the connecting surfaces. For example, on the aluminized connecting surfaces of chips a Cr-Cu-Au coating sequence is applied under vacuum and possibly electrolytically reinforced. On the contact areas prepared in this manner a layer of lead-rich soft solder is evaporated in a structured manner. Through fusion the solder mounds bond well with the contact areas.

Another way to belay chips with contact material is the external production of the contact material mound elements and their subsequent attachment on the element to be fitted with contact material. In this context it is known to prepare solder material in the form of small plates or in the shape of spheres, to distribute over the connecting surfaces and to fuse them on. For this purpose it is useful to configure the connecting surfaces in a slightly concave shape.

For the sake of high volume production it is not possible to adjust the integrated circuits to accommodate all customer wishes. The user helps himself by composing his assembly from several ICs possibly supplementing them with discrete components. The high spatial integration of the circuit is partially lost in this process. The surface of the wiring carriers must be significantly enlarged or additional wiring carriers will be needed. This, however, means a partial loss of the high density of integration incorporated in the compact circuit or in the compact circuit arrangement.

The invention is based on the task of increasing the combinability of elements in a vertical direction, by externally producing mound elements of practically equal elevation and by contacting them on the parts that need to be fitted with contact mounds.

This task is solved according to the invention in that, in a compact circuit arrangement with one or several circuits and/or one or several wiring carriers that are contacted with and among each other, aside from the contact elements, at least one functional element is positioned between the parts that are vertically contacted on top of each other. The term "functional element" in this context shall mean an element with an electronic function that exceeds that of being a mere conductive connection. It is, e.g., possible to isolate contact elements from a silicon disc and to dope them as conductors. Likewise, a variety of functional elements such as diodes,

resistors, sensors etc., can be produced on a silicon disk and can be vertically integrated into the compact circuit group. This produces a large number of variants. In particular, elements that are characteristic for an assembly and of which often only one single unit or a small number of units is present or special smaller electrical functional groups at the inputs and outputs of a circuit, can be integrated into the compact circuit arrangement without requiring additional space.

In this way, e.g., a compact circuit arrangement is possible with a temperature sensor, a Peltier element and with a control circuit, wherein between a wiring carrier beside contact elements out of conductive doped semiconductor material that have been isolated from a semiconductor material disc, functional elements are positioned that are made from doped semiconductor material with the same dimensions as the contact elements, more precisely: at least one p-type and one n-type doped functional element that are contacted with each other and a diode doped as a temperature sensor.

In addition, the compact circuit arrangement can be fitted with an oscillator quartz, with a battery and with a liquid crystal display, with the oscillator quartz positioned, together with contact elements made from a semiconductor material, and possibly other functional elements, between the circuit and the wiring carrier.

Preferably, in a compact circuit arrangement with optical couplers, parts of the optical couplers are made to the same dimensions as are those of contact elements that are isolated from semiconductor discs. In this arrangement luminescent diodes and photo diodes in the circuit and in the wiring carrier, both preferably made from GaAs, can be doped and between them transparent bodies with the dimensions of the contact elements can be attached.

The functional element(s) preferably have the same height as the contact elements and the functional and contact elements are made from silicon, another semiconductor material, a ferroelectric material, a dielectric material or another material with electronic applications.

For the modulation of polarized electromagnetic irradiation a double-refracting crystal, preferably out of CdTe, is contacted between a circuit and a wiring carrier together with contact elements of approximately the same dimensions. Preferably, one functional element features at least two connectors on one connecting side. Between the circuit and the wiring carrier at least one Peltier element can be provisioned that consists of two semiconductor elements one of which is doped as a p-type conductor, the other one as an n-type conductor.

Other functional elements can be capacitors, electrochemical energy sources, thermistors, varistors, magnetic resistors elements or functional elements out of Piezo ceramic material.

According to the process for depositing contact material on connecting surfaces according to the invention, contact elements that have been doped to be conductors are isolated from a silicon disc or from a disc of another semiconductor material and contacted on the connecting surfaces of a circuit or of a substrate.

The contact elements can be manufactured with very small tolerances. The individual contact elements that are isolated from the disc can be considered as being of equal height. When isolating by way of sawing, the other dimensions can also be produced with small tolerances. This offers the possibility of manufacturing cube-shaped contact elements for certain applications that through the equal length of the edges facilitate manipulation during contacting. The contact element can be doped with aluminum to the point of saturation and be made conductive in this fashion.

The processes for the contacting of such contact elements must be adjusted to fit each individual application and doping situation.

Preferably, the contact elements can be contacted onto the part on which contacting material needs to be deposited by way of TC bonding and subsequently the opposite connecting surfaces of the contact elements can be prepared for simultaneous contacting of the part to be fitted with contact material by way of soldering, gluing, carrier film bonding or by way of wire contacting.

The invention is explained based on several embodiment samples. The figures show:

Figure 1, compact circuit arrangement with a capacitor and a resistor

Figure 2, compact circuit arrangement with an intermediate carrier

Figure 3, compact circuit arrangement with additional functional elements

Figure 4, compact circuit arrangement with additional wiring

Figure 5, compact circuit arrangement with an oscillator quartz

Figure 6, cross sectional view of a chip internally contacted by means of carrier film bonding.

The compact circuit arrangement according to Figure 1 consists of a circuit (chip) 1 with its connecting surfaces 2 that extend along its edge or over its entire surface. Upon the connecting surfaces 2 cube-shaped or right parallelepipedon-shaped contact elements out of conductive doped silicon are contacted that are of practically identical height and of which one is shown in the drawing. Next to a contact element 3 two functional elements, a resistor element 7 and a capacitor element 8, are contacted on the connecting surfaces 2. The thus equipped chip 1 is contacted via the contact layers 4 with the connecting surfaces 5 of a wiring carrier 6.

The resistor element 7 consists of low-doped silicon. The mini-capacitor 8 is made from barium strontium titanate that is metallized on both sides. Obviously, other materials can be used for this purpose, as well. For example, the resistor element can also be isolated from a Cr-Ni film and the capacitor can also be configured as an air capacitor. In the latter case the functional element would consist of the two connecting surfaces. The functional element can also consist of irradiation-sensitive material e.g. of a material that is permeable for optical or IR irradiation.

In Figure 2 a compact circuit arrangement is shown with an intermediate carrier 9. The contact elements and the functional elements are positioned between the circuits 1 and the intermediate carrier 9 and also between the latter and a wiring carrier 6. The conductive connections between the upper and the lower level of the intermediate carrier are possible by way of through-contacts 13 and edge metallizations 14 or via an upper and lower soldering point 11 and 12 by way of metal yokes 10. The resistor elements are configured as an ohmic resistor 7.1, as a magnetoresistor 7.2 and/or as a varistor 7.3.

In Figure 3 additional functional elements are positioned side by side in order to indicate at least one of the many variants of possible combinations that can be chosen from. In a right to left sequence the following is shown in the drawing: a contact element 3, a homo junction diode 16.0, a transparent contact element 15, a Schottky diode 16.1, an infrared sensitive photo diode 16.2 for vertical irradiation though the circuit 1, a photo diode 16.3 with lateral light entry, a semiconductor laser diode 16.4 with lateral light emission and with the possibility of optical coupling to the adjacent photo diode 16.3, luminescent diode 16.5, an electrochemical voltage source 17 and a semiconductor structure 18 featuring two connections on one connecting side.

In Figure 4 contact elements 3 are connected among each other on circuit 1 by way of additional wiring and a contact element 3 on the wiring carrier 6 is connected with the connections of the assembly by means of connecting wiring 20.

In Figure 5 a cross sectional view is shown of a compact circuit arrangement configured according to the invention with an oscillator quartz for a digital watch. A circuit 1 is contacted via contact elements 3 with a wiring carrier 6. On the other side of the wiring carrier a liquid crystal display 26 is connected (also via contact elements 3).

Next to the contact element 3, functional elements, a battery 22, an oscillator quartz 23, a thermistor 24, capacitors 8 and a Peltier element 25 are contacted between the circuit and the wiring carrier. The contact and the functional elements are first bonded onto the connecting surfaces 2 of the circuit 1 by means of thermocompression. Simultaneously, the circuit on which this contact material is deposited is connected with the wiring structures 21 of the wiring carrier 6 via the contact layers 4. One capacitor is configured to be adjustable. Between the capacitor surfaces 8.1 a dielectric material 8.2 is inserted and fixed in its places by means of glue 8.3. Of course, mechanical variants of the type of a rotating capacitor or with a drive spindle can here be inserted, as well. The Peltier element consists of one arm with p-type conductivity 25.1 and another one with n-type conductivity 25.2. With the poles reversed it can be used as a heater. The wiring carrier is contacted through.

If the compact circuit arrangement is used for the modulation of polarized irradiation, it is useful if the circuit, the wiring carrier and the contact elements consist of the same material as

the crystal. Advantageously, printed circuitry conductors can be vacuum metallized on both sides of the crystal and the crystal can be contacted via ring electrodes.

Preferably, the compact circuit arrangement is encased gas-tight and the encasement filled with a highly effective insulating medium preferably sulfur hexafluoride. Below the process for depositing contact material will be explained on the basis on a sample.

Figure 1 shows a cross sectional view of a compact circuit arrangement. A circuit 1 with its connecting surfaces 2 out of aluminum is connected with the connecting surfaces 5 of a substrate 6 via contact elements 3. The contact elements 3 have been isolated from a silicon disc, doped conductive with aluminum and have been contacted onto the connecting surfaces 2 by means of TC bonding. The chip 1 on which contact material has been deposited is attached to the substrate by means of conductive glue 4. The glue layer 4 provides the height level adjustment in the event that the substrate is undulated. When a second circuit or substrate out of silicon is connected, the glue layer can be kept very thin. Aside from this, this combination prevents heat stress from occurring.

Figure 6 shows how the chip 1, on which again contacting material has been deposited, is bonded by means of a carrier film 27. Special measures of the individual technologies, that are adopted for optimization, from the pertinent state of the art have not been mentioned or shown in the drawing. For example, based on current knowledge about thermocompression it is necessary that between two silicon parts that are to be contacted that a ductile layer of at least 5 μm thickness exist, preferably out of aluminum. Thus, if contact material of a thickness of 1 μm approx. is to be deposited on circuits with connecting surfaces out of aluminum, it goes without saying that the contact elements are to be coated prior to TC bonding with a thin aluminum layer at least at the contact surface with the circuit.

List of Designations

1 Circuit
2 Connecting surface
3 Contact element
4 Contact layer, conductive glue
5 Printed circuit connection
6 Wiring carrier
7 Resistor element
  7.1 Ohmic resistor
  7.2 Magneto-resistor
  7.3 Varistor
8 Capacitor element

8.1 Capacitor plates
8.2 Dielectric material
8.3 Glue
9 Intermediate carrier
10 Metal yoke
11 Upper soldering point
12 Lower soldering point
13 Through-contact
14 Edge metallization
15 Transparent contact element
16 Diode
16.0 Homo junction diode
16.1 Schottky diode
16.2 Photo diode with vertical irradiation
16.3 Photo diode with parallel irradiation
16.4 Semiconductor laser diode
16.5 Luminescent diode
17 Electrochemical energy source
18 Semiconductor structure with two connections
19 Additional wiring
20 Connecting wiring
21 Wiring structure
22 Battery
23 Oscillator quartz
24 Thermistor
25 Peltier element
25.1 p-type doped semiconductor element
25.1 n-type doped semiconductor element
26 Liquid crystal display
27 Carrier film

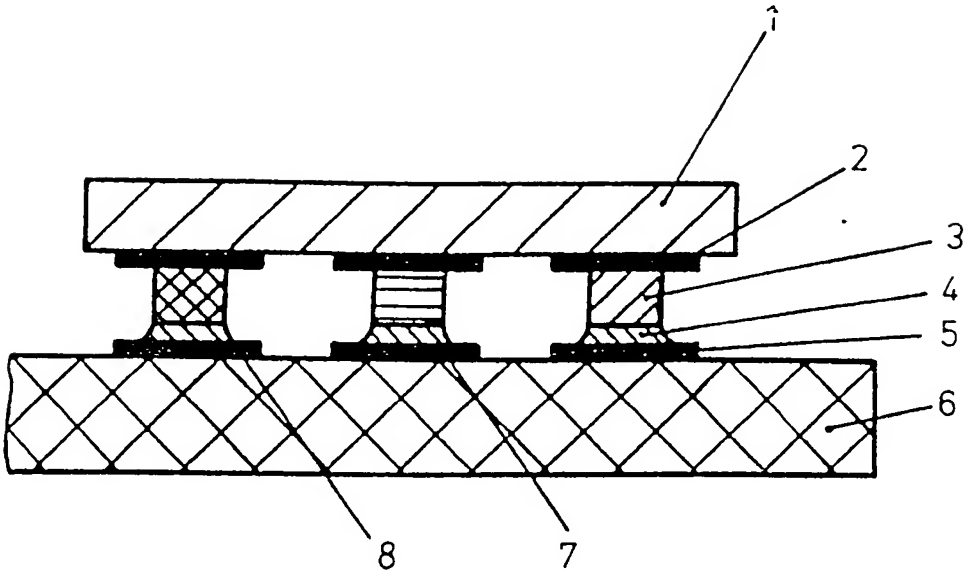


Fig.1

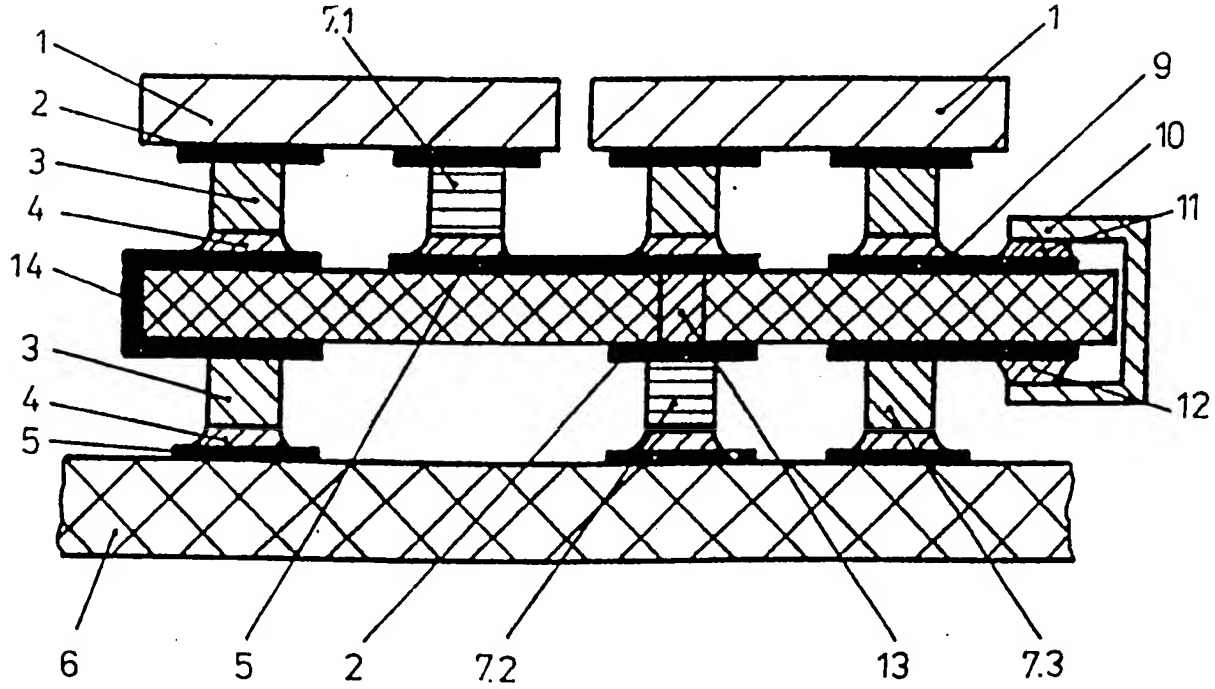


Fig. 2

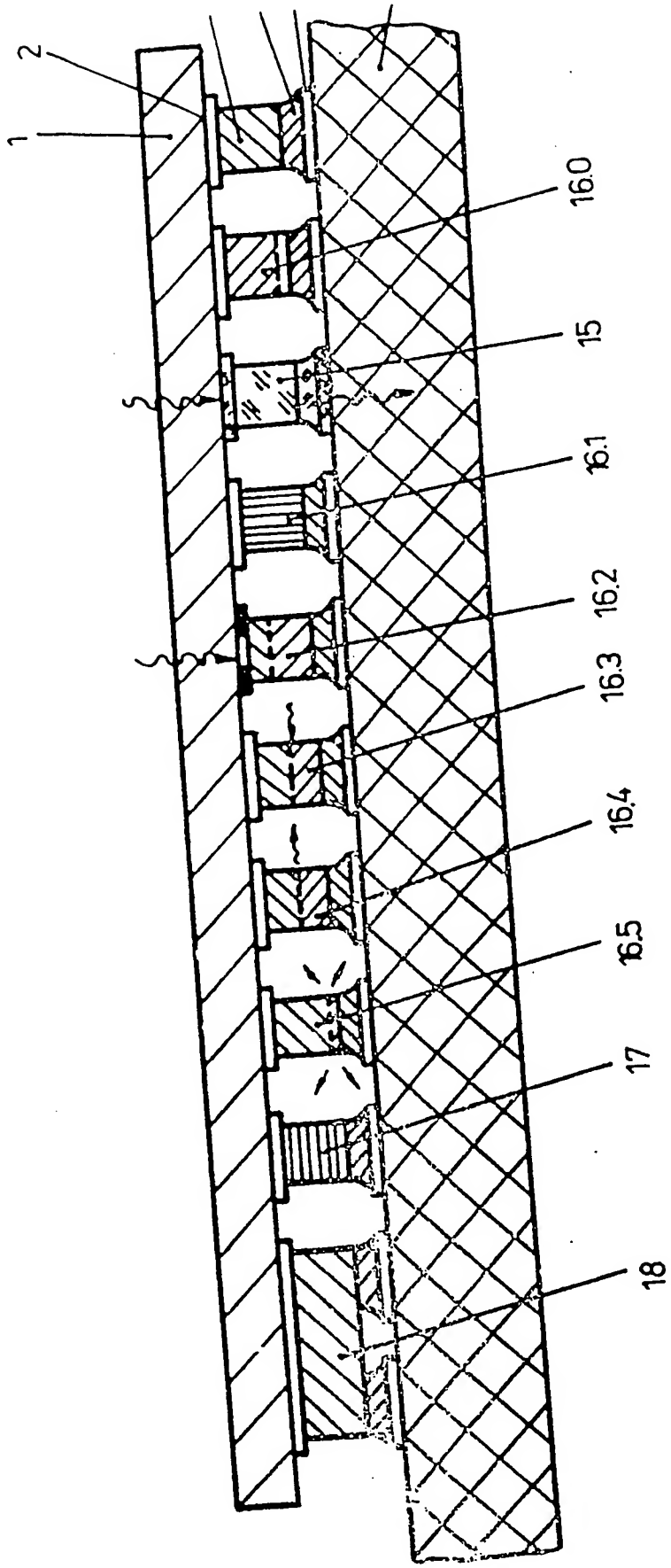


Fig. 3

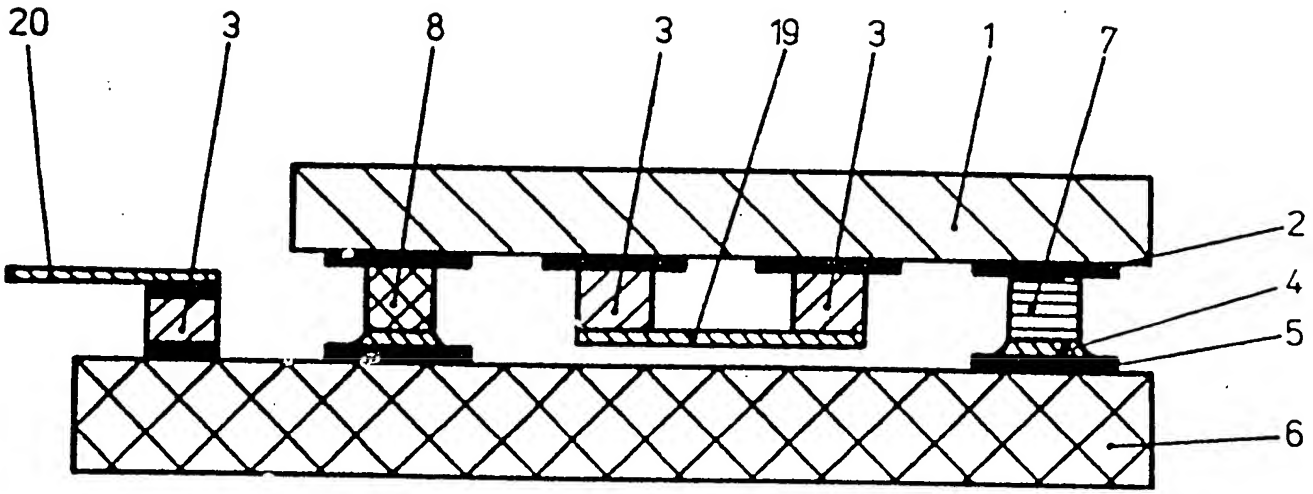


Fig.4

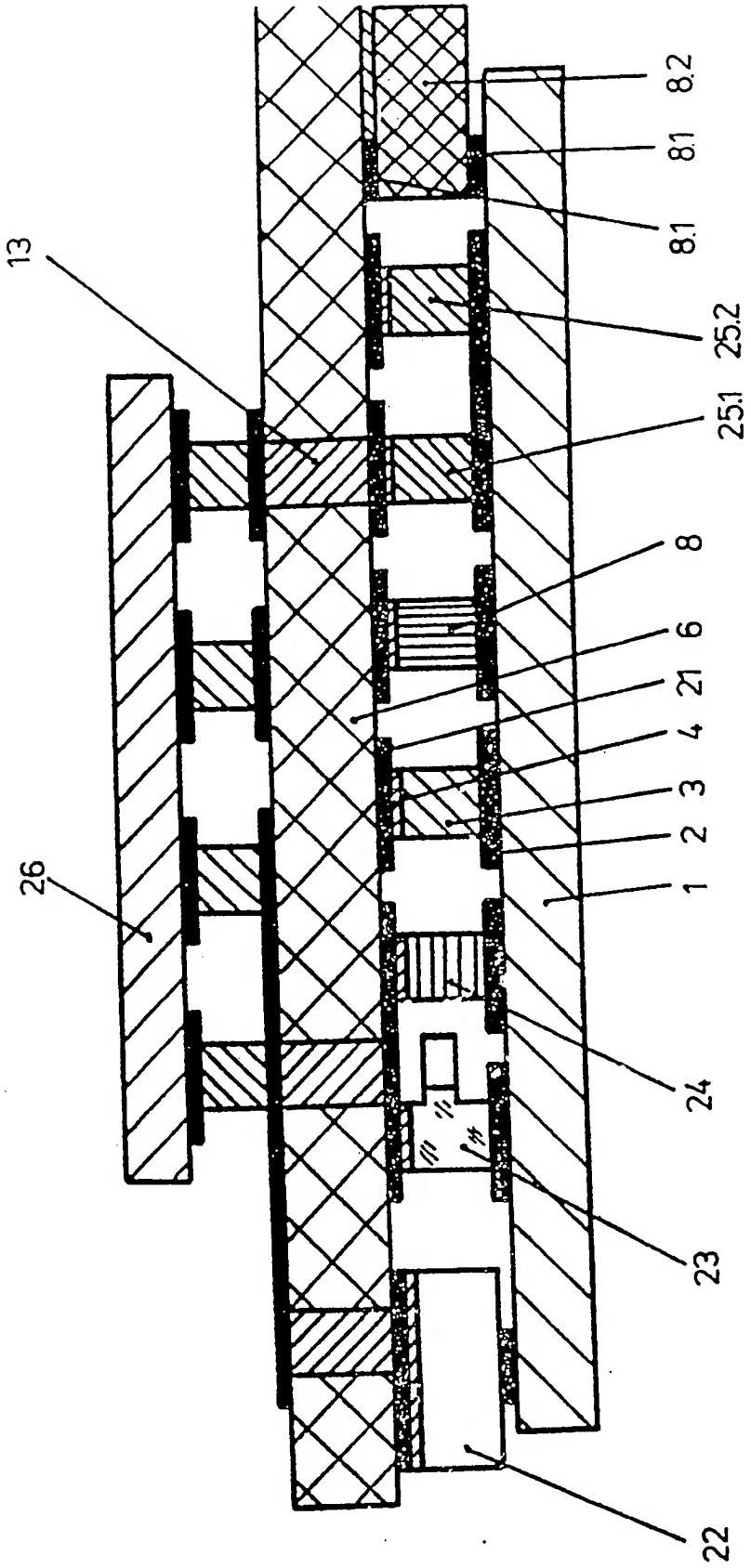


Fig.5

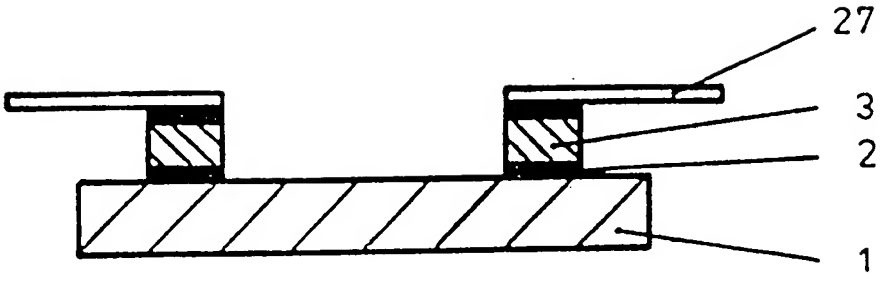


Fig. 6